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(71) Applicant: **Shanghai Bilibili Technology Co., Ltd**
Yangpu District
Shanghai 200433 (CN)

(72) Inventors:
- **WU, Zhiqiang**
  Shanghai 200433 (CN)
- **ZHENG, Hanchao**
  Shanghai 200433 (CN)
- **CHEN, Hui**
  Shanghai 200433 (CN)
- **DING, Jianqiang**
  Shanghai 200433 (CN)
- **TAN, Zhaoxin**
  Shanghai 200433 (CN)

(74) Representative: **Isarpatent**
Patent- und Rechtsanwälte Barth
Charles Hassa Peckmann & Partner mbB
Friedrichstrasse 31
80801 München (DE)

(54) DEFINITION SWITCHING METHOD AND APPARATUS, COMPUTER DEVICE, AND READABLE STORAGE MEDIUM

(57) The present application discloses a method and device of switching resolution, a computing device, and a readable storage medium, the method includes: in playing audio and/or video using DASH, acquiring a media presentation description (MPD) file and obtaining resolution information through parsing the MPD file; during the playing of the audio and/or video, periodically determining a currently secure downloading speed according to a preset time interval and determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information; and in accordance with a determination that the resolution switching is required, determining a switching time point according to an elapsed duration of a currently playing segment and a preset secure buffering duration and performing resolution switching at the switching time point. The present application can automatically switch the resolution according to the current downloading speed without any stuttering.

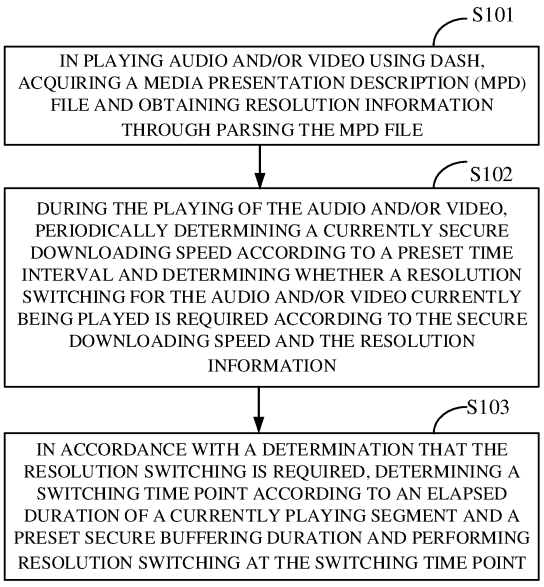

Fig. 1

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Description

CROSS REFERENCE TO RELATED APPLICATION

[0001] The present application claims priority to Chinese patent application No. 201910091813.9, filed on January 30, 2019, entitled "method and device of switching resolution, computing device, and readable storage medium", the entire contents of which are hereby incorporated by reference in their entirety for all purposes.

TECHNICAL FIELD

[0002] The present application relates to a technical field of audio and video playing, and particularly to a method and device of switching resolution, a computing device, and a readable storage medium.

BACKGROUND

[0003] To make audio and video play more smoothly, more and more video websites have begun to use Dynamic Adaptive Streaming over HTTP (DASH) technology, which is an adaptive bitrate streaming technology and enables high-quality streaming media to be delivered over the Internet through a traditional HTTP web server; DASH splits a streaming media content into multiple segments, each segment contains a certain length (e.g., 10 seconds) of playable content, and each segment is corresponding to multiple resolutions (e.g., 1080P, 720P, 480P, 360P), and a client can choose to download and play the segments with a specified resolution according to current network conditions. Compared with traditional audio and video playing technologies, it is not required to reload a player when switching a resolution. However, inventors found that when using DASH, it is not intelligent enough to switch the resolution according to a selection of a user; in addition, since the segments are required to be downloaded and buffered, in a process of resolution switching, there will be situations where a current segment has been played completely but a next segment has not been downloaded yet, causing a playing freeze and affecting user's experience.

SUMMARY

[0004] The object of the present application is to provide a method and device of switching resolution, a computing device, and a readable storage medium, thereby the resolution switching is performed automatically according to a current downloading speed, and a phenomenon of switching freeze will not occur.

[0005] One aspect of the present application provides a method of switching resolution, the method includes:

in playing audio and/or video using DASH, acquiring a media presentation description (MPD) file and obtaining resolution information through parsing the MPD file;
during the playing of the audio and/or video, periodically determining a currently secure downloading speed according to a preset time interval and determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information; and
in accordance with a determination that the resolution switching is required, determining a switching time point according to an elapsed duration of a currently playing segment and a preset secure buffering duration and performing resolution switching at the switching time point.

[0006] Optionally, the resolution information includes multiple usable resolutions and bandwidths corresponding to respective ones of the multiple resolutions.

[0007] Optionally, the periodically determining a currently secure downloading speed according to a preset time interval includes:

obtaining playing information of N segments before the currently playing segment;
calculating an actual downloading speed of each segment based on the playing information of each segment, and calculating an average downloading speed according to actual downloading speeds of the N segments; and
multiplying the average downloading speed by a preset secure factor and a percentage to obtain the currently secure downloading speed.

[0008] Optionally, the playing information includes: a connection establishment duration, a downloading duration, and a total downloading byte count; and
the calculating an actual downloading speed of each segment based on the playing information of each segment includes:

the actual downloading speed = (8× the total downloading byte count)/(the connection establishment duration + the downloading duration).

[0009] Optionally, the secure factor is 0.8;

the percentage K is calculated according to a formula of: K=(D-L)/D;
wherein D is a playing duration of one segment; and
L is an average connection establishment duration calculated according to connection establishment durations of the N segments.

[0010] Optionally, the determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information includes:
adjusting resolutions of subsequently playing segments to be just less than a resolution corresponding to the bandwidth of the secure downloading speed.

[0011] Optionally, the determining a switching time point according to an elapsed duration of a currently playing segment and a preset secure buffering duration and performing resolution switching at the switching time point includes:
calculating the switching time point T according to a formula of:

$$T=\mathrm{ceil}\left(\frac{C+Q}{D}\right)$$

wherein ceil( ) is a round up function;

C is the elapsed duration of the currently playing segment; and
Q is the secure buffering duration, and Q is equal to 1.5 times the playing duration of one segment; and
the resolution switching is performed when playing a T-th segment behind the current segment.

[0012] To achieve the above object, the present application further provides a device of switching resolution, the device includes:

a parsing module for acquiring a media presentation description (MPD) file and obtaining resolution information through parsing the MPD file, when audio and/or video is played using DASH;
a determining module for, during the playing of the audio and/or video, periodically determining a currently secure downloading speed according to a preset time interval and determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information; and
a switching module for, in accordance with a determination that the resolution switching is required, determining a switching time point according to an elapsed duration of a currently playing segment and a preset secure buffering duration and performing resolution switching at the switching time point.

[0013] To achieve the above object, the present application further provides a computing device including a memory, a processor, and computer-readable instructions stored in the memory and operable on the processor, wherein the processor, when executing the computer-readable instructions, implements steps of:

in playing audio and/or video using DASH, acquiring a media presentation description (MPD) file and obtaining resolution information through parsing the MPD file;
during the playing of the audio and/or video, periodically determining a currently secure downloading speed according to a preset time interval and determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information; and
in accordance with a determination that the resolution switching is required, determining a switching time point according to an elapsed duration of a currently playing segment and a preset secure buffering duration and performing resolution switching at the switching time point.

[0014] To achieve the above object, the present application further provides a computer-readable storage medium storing computer-readable instructions that upon execution by a processor cause the processor to implement steps of:

in playing audio and/or video using DASH, acquiring a media presentation description (MPD) file and obtaining resolution information through parsing the MPD file;
during the playing of the audio and/or video, periodically determining a currently secure downloading speed according to a preset time interval and determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information; and
in accordance with a determination that the resolution switching is required, determining a switching time point according to an elapsed duration of a currently playing segment and a preset secure buffering duration and performing resolution switching at the switching time point.

[0015] The method and device of switching resolution, the computing device, and the readable storage medium provided by the present application can periodically determine whether a resolution switching is required according to a currently secure downloading speed under a preset time interval, and automatically perform resolution switching at calculated switching time points; since a connection establishment time and a network jitter of obtaining segments are taken into account when calculating the secure downloading speed, current network speed can be guaranteed to meet a bandwidth requirement of the resolution after the resolution switching; in addition, performing resolution switching at the switching time points can avoid the situations where the segment corresponding to the resolution after the resolution switching has not been downloaded yet, but the segment corresponding to current resolution has been finished playing, thereby, seamless switching of audio and/or video is ensured, and a phenomenon of switching freeze will not occur.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Upon reading the detailed description of the preferred embodiments below, various other advantages and benefits will become apparent to those of ordinary skill in the art. The drawings are only for the purpose of illustrating preferred embodiments and are not to be considered as limiting the present application. Moreover, the same reference numerals are used throughout the drawings to refer to the same parts. In the drawings:

Fig. 1 illustrates an optional flowchart of a method of switching resolution provided by a first embodiment;
Fig. 2 illustrates a schematic diagram of a content structure of an MPD file in the first embodiment;
Fig. 3 illustrates an optional schematic diagram of a program module of a device of switching resolution provided by a second embodiment;
Fig. 4 illustrates an optional diagram of hardware architecture of a computing device provided by the third embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

[0017] To make the objectives, technical solutions, and advantages of the present application more comprehensible, the present application is described in further detail below with reference to embodiments and the accompanying drawings. It should be understood that the specific embodiments described herein are merely used for explaining the present application, and are not intended to limit the present application. All other embodiments obtained by those skilled in the art based on the embodiments of the present application without creative efforts shall fall within the protection scope of the present application.

[0018] The first embodiment

[0019] The method of switching resolution provided by the present application is described below with reference to the accompanying drawings.

[0020] Fig. 1 illustrates an optional flowchart of a method of switching resolution provided by a first embodiment, and the method is applied to a DASH client. As shown in Fig. 1, the method may include the following steps:
Step S101, in playing audio and/or video using DASH, acquiring an MPD file and obtaining resolution information through parsing the MPD file.

[0021] Specifically, the resolution information includes multiple usable resolutions and bandwidths corresponding to respective ones of the multiple resolutions.

[0022] Further, the MPD file is a media presentation description file of the audio and/or video, which can be used to describe composition of the entire MPEG DASH (also known as DASH) code streaming, being equivalent to M3U8 (M3U8 is a kind of video format) file in the HTTP Live Streaming (HLS) protocol, the MPD file is an XML (Extensible Markup Language) Document (Document is a computer term, and each Hyper Text Markup Language (HTML) document loaded into a browser is a Document object), content of the MPD file can be used to construct URLs (Uniform Resource Locator) of HTTP GET requests (HTTP GET request is a way of HTTP request) for downloading.

[0023] As shown in Fig. 2, illustrating a schematic diagram of content structure of the MPD file in XML format, the MPD file in XML format includes multiple segment Period files; each of the Period files has a corresponding AdaptationSet

file for application description; one AdaptationSet file contains Representation files for resolution descriptions of different resolutions or streams, each of the Representation files is corresponding to a resolution, and each of the Representation files contains a bandwidth requirement for the corresponding resolution; one Representation file contains a plurality of segments, and each segment is corresponding to a video content or audio content for a certain time length.

[0024] In the MPD file in XML format, streaming media content is placed into a Period segment; video data and audio data in the streaming media content are separately stored into different AdaptationSet segments; videos or audios of different resolutions are represented by different Representation segments; and video attribute information or audio attribute information is included in one Representation segment.

[0025] Further, the obtaining resolution information through parsing the MPD file includes:

obtaining usable resolutions and bandwidths corresponding to respective ones of the resolutions though parsing the Representation file in the MPD file.

[0026] Preferred, in practical applications, a resolution list can be obtained by parsing the MPD file, and the resolution list includes index values, information of resolutions, information of bandwidths corresponding to the resolutions, and information of URLs (Uniform Resource Locator) of the audio or video.

[0027] Step S 102, during the playing of the audio and/or video, periodically determining a currently secure downloading speed according to a preset time interval and determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information.

[0028] Specifically, the periodically determining the currently secure downloading speed according to a preset time interval includes:

step A1, obtaining playing information of N segments before the currently playing segment; wherein N is a positive integer;

further, the playing information includes: a connection establishment duration, a downloading duration, and a total downloading byte count;

wherein the connection establishment duration is duration from the time when the DASH client sends a request to the HTTP server to the time when the DASH client receives the response returned by the HTTP server;

the downloading duration is duration from the time when the DASH client starts downloading audio and/or video based on the received response to the time when the downloading is ended; and

the total downloading byte count is total number of bytes consumed for downloading the audio and/or video.

[0029] In the embodiment, whenever a segment is downloaded, the DASH client will obtain the total downloading byte count from file header of a segment file, count the connection establishment duration and the downloading duration of the segment, and store total downloading byte count, the connection establishment duration, and the downloading duration of the segment for later use in calculating the secure downloading speed.

[0030] Step A2, calculating an actual downloading speed of each segment based on the playing information of each segment, and calculating an average downloading speed according to actual downloading speeds of the N segments;

[0031] further, the calculating an actual downloading speed of each segment based on the playing information of each segment includes: the actual downloading speed = (8× the total downloading byte count) / (the connection establishment duration + the downloading duration).

[0032] The calculating an average downloading speed according to actual downloading speeds of the N segments includes:

$$\text{the average downloading speed} = (\text{a first actual downloading speed} + \text{a second actual downloading speed} + \ldots\ldots + \text{an N-th actual downloading speed})/N.$$

[0033] Step A3, multiplying the average downloading speed by a preset secure factor and a percentage to obtain the currently secure downloading speed.

[0034] Further, the percentage K is calculated according to a formula of:

$$K=(D-L)/D;$$

wherein D is a playing duration of one segment;

L is an average connection establishment duration calculated according to connection establishment durations of the N segments, and L<D.

[0035] The Step A3 includes:

$$\text{the secure downloading speed} = \text{the average downloading speed} \times P \times K;$$

wherein P is the secure factor; preferred, P is 0.8.

[0036] In the embodiment, the influence of the average connection establishment duration during downloading the segment is considered when calculating the secure downloading speed; since the duration from sending the segment downloading request by the DASH client to the HTTP server to finishing downloading the segment includes the connection establishment duration and the downloading duration, the total duration of downloading the segment is the sum of the connection establishment duration and the downloading duration; since the total duration of downloading the segment cannot exceed the playing duration of the segment, the maximum downloading duration of the segment is the difference between the playing duration of the segment and the connection establishment duration of the segment; therefore, the percentage K indicates a proportion of the maximum downloading duration of the segment to the playing duration of the segment. In addition, in the embodiment, a network jitter is also taken into account when calculating the secure downloading speed, and the current downloading speed is guaranteed to be sufficient to meet the bandwidth requirements of certain resolutions by the secure factor P.

[0037] Further, the determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information includes:
adjusting resolutions of subsequently playing segments to be just less than a resolution corresponding to the bandwidth of the secure downloading speed.

[0038] In practical applications, the calculated secure downloading speed can be compared with the bandwidth requirements of each resolution in the resolution list to determine the maximum resolution that the current secure downloading speed can support. For example, the current secure downloading speed is 120Mbps, and according to the resolution information, the available resolutions include 1080P, 720P, 480P, 360P; the bandwidth requirement of 1080P is 150Mbps, the bandwidth requirement of 720P is 100Mbps, the bandwidth requirement of 480P is 50Mbps, and the bandwidth requirement of 360P is 25Mbps; since the current secure downloading speed can meet the bandwidth requirement of 720P, the resolution of the segments being played afterward is adjusted to 720P.

[0039] Further, before the step S 102, the method further includes:

calculating the average connection establishment duration according to connection establishment durations of the N segments before the currently playing segment;
determining whether the average connection establishment duration is larger than the playing duration of one segment;
if yes, adjusting the resolution of the audio and/or video to be played later to the minimum; and
if not, step S102 is executed.

[0040] If the average connection establishment duration is larger than the playing duration of one segment, it means that the next segment cannot be fully downloaded before the current segment is played completely, that is, the audio and/or video of the current resolution cannot be played smoothly; in this situation, the DASH client will minimize the resolution of the audio and/or video currently being played.

[0041] In the embodiment, whether to perform resolution switching is determined periodically according to a preset time interval (for example, whether to perform resolution switching is determined every 500 seconds); when the determination is performed, the average downloading speed is calculated according to actual downloading speed of the N (for example, N is 10) segments closest to the current segment, and the secure downloading speed is calculated considering the connection establishment duration and the network jitter; and based on the secure downloading speed, the resolution of the audio and/or video played later is adjusted to the resolution that is sufficiently supported by the secure downloading speed.

[0042] Step S103: in accordance with a determination that the resolution switching is required, determining a switching time point according to an elapsed duration of a currently playing segment and a preset secure buffering duration and performing resolution switching at the switching time point.

[0043] Specifically, step S103 includes:
calculating the switching time point T according to a formula of:

$$T = \text{ceil}\left(\frac{C+Q}{D}\right)$$

wherein ceil( ) is a round up function;

C is the elapsed duration of the currently playing segment; and
Q is the secure buffering duration, and Q is equal to 1.5 times the playing duration of one segment; and
the resolution switching is performed when playing a T-th segment behind the current segment.

[0044] For example, when the value of (C+Q)/D is 3.4, the value of T is 4; after the current segment is completely played, and when the fourth segment is played, the resolution switching is performed.

[0045] In the embodiment, in order to avoid the situations where the segment corresponding to current resolution has been finished playing, but the segment corresponding to the resolution after the resolution switching has not been downloaded yet, sufficient downloading time is ensured for the segments after the resolution switching through calculating the switching time point, thereby, seamless switching of audio and/or video is ensured, and a phenomenon of switching freeze will not occur.

[0046] The second embodiment

[0047] A device of switching resolution is provided in this embodiment, based on the method of switching resolution provided in the first embodiment above, specifically, Fig. 3 illustrates an optional schematic diagram of the device of switching resolution, the device of switching resolution is divided into one or more program modules, and the one or more program modules are stored in a storage medium and executed by one or more processors to complete the present application. The program modules referred to in the application refer to a series of computer-readable instruction segments capable of performing specific functions, the following description will specifically introduce the functions of each of the program modules in the embodiment.

[0048] As shown in Fig. 3, the device of switching resolution applied to a DASH client includes following components: a parsing module 301 for acquiring a media presentation description (MPD) file and obtaining resolution information through parsing the MPD file, when audio and/or video is played using DASH.

[0049] Specifically, the resolution information includes: multiple usable resolutions and bandwidths corresponding to respective ones of the multiple resolutions.

[0050] Further, the parsing module 301 specifically for:
obtaining usable resolutions and bandwidths corresponding to respective ones of the resolutions though parsing the Representation file in the MPD file.

[0051] A determining module 302 for, during the playing of the audio and/or video, periodically determining a currently secure downloading speed according to a preset time interval and determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information. Specifically, the determining module 302 includes:

an obtaining unit for, obtaining playing information of N segments before the currently playing segment;
a calculating unit for, calculating an actual downloading speed of each segment based on the playing information of each segment, and calculating an average downloading speed according to actual downloading speeds of the N segments;
a processing unit for, multiplying the average downloading speed by a preset secure factor and a percentage to obtain the currently secure downloading speed; and
a switching unit for, adjusting resolutions of subsequently playing segments to be just less than a resolution corresponding to the bandwidth of the secure downloading speed.

[0052] Further, the playing information includes: a connection establishment duration, a downloading duration, and a total downloading byte count.

[0053] The calculating unit is specifically used for:

calculating an actual downloading speed of each segment according to a formula of:

$$\text{the actual downloading speed} = (8\times \text{the total downloading byte count})/(\text{the connection establishment duration} + \text{the downloading duration});$$

calculating an average downloading speed of the N segments according to a formula of:

$$\text{the average downloading speed} = (\text{a first actual downloading speed} + \text{a second actual downloading speed} + \ldots\ldots + \text{an N-th actual downloading speed})/N.$$

[0054] Further, the processing unit is used for:

calculating the percentage K according to a formula of:

$$K=(D-L)/D;$$

wherein D is a playing duration of one segment;
L is an average connection establishment duration calculated according to connection establishment durations of the N segments;

calculating the secure downloading speed according to a formula of:

$$\text{the secure downloading speed} = \text{the average downloading speed} \times P \times K;$$

[0055] Wherein P is the secure factor, preferred, P is 0.8.

[0056] A switching module 303 for, in accordance with a determination that the resolution switching is required, determining a switching time point according to an elapsed duration of a currently playing segment and a preset secure buffering duration and performing resolution switching at the switching time point.

[0057] Specifically, the switching module 303 is used for:
calculating the switching time point T according to a formula of:

$$T=\text{ceil}\left(\frac{C+Q}{D}\right)$$

wherein ceil( ) is a round up function;

C is the elapsed duration of the currently playing segment; and
Q is the secure buffering duration, and Q is equal to 1.5 times the playing duration of one segment; and
the resolution switching is performed when playing a T-th segment behind the current segment.

[0058] The third embodiment

[0059] This embodiment also provides a computing device, such as a smartphone, a tablet computer, a notebook computer, a desktop computer, a rack server, a blade server, a tower server, or a rack server (including a stand-alone server, or server cluster consisting of multiple servers), and so on that can execute programs. As shown in Fig. 4, the computing device 40 of the embodiment includes at least, but not limited to: a memory 401 and a processor 402 that can be communicatively connected to each other through a system bus. It should be noted that Fig. 4 only shows the computing device 40 having the components 401-402, but it should be understood that not all components shown are required to be implemented, and more or fewer components may be implemented instead.

[0060] In the embodiment, the memory 401 (i.e., readable storage medium) includes a flash memory, a hard disk, a multimedia card, a card-type memory (such as SD or DX memory and so on), a random access memory (RAM), a static random access memory (SRAM), a read-only memory (ROM), an electrically erasable programmable read-only memory (EEPROM), a programmable read-only memory (PROM), magnetic memory, magnetic disks, optical disks and so on. In some embodiments, the memory 401 may be an internal storage unit of the computing device 40, such as a hard disk or a memory of the computing device 40. In other embodiments, the memory 401 may also be an external storage device of the computing device 40, such as a plug-in hard disk, a smart media card (SMC), and a Secure Digital (SD) card, a Flash Card and so on. Of course, the memory 401 may also include both the internal storage unit of the computing device 40 and its external storage device. In the embodiment, the memory 401 is generally used to store an operating system and various types of application software installed in the computing device 40, such as program codes of the device of switching resolution in the second embodiment. In addition, the memory 401 can also be used to temporarily store various types of data that have been output or will be output.

[0061] The processor 402 may be a Central Processing Unit (CPU), a controller, a microcontroller, a microprocessor, or other data processing chips in some embodiments. The processor 402 is generally used to control the overall operation of the computing device 40.

[0062] Specifically, in the embodiment, the processor 402 is configured to execute a program of a method of switching resolution stored in the processor 402, and when the program of the method of switching resolution is executed, the

following steps are implemented:

in playing audio and/or video using DASH, acquiring a media presentation description (MPD) file and obtaining resolution information through parsing the MPD file;
during the playing of the audio and/or video, periodically determining a currently secure downloading speed according to a preset time interval and determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information; and
in accordance with a determination that the resolution switching is required, determining a switching time point according to an elapsed duration of a currently playing segment and a preset secure buffering duration and performing resolution switching at the switching time point.

[0063] A specific embodiment and process of the foregoing method steps can refer to the first embodiment, which is not repeatedly described in this embodiment.

[0064] The fourth embodiment

[0065] This embodiment also provides a computer-readable storage medium (volatile or nonvolatile), such as a flash memory, a hard disk, a multimedia card, a card-type memory (for example, SD or DX memory and so on), a random access memory (RAM), a static random access memory (SRAM), a read-only memory (ROM), an electrically erasable programmable read-only memory (EEPROM), a programmable read-only memory (PROM), a magnetic memory, magnetic disks, optical disks, servers, App Store and so on, which stores computer-readable instructions that upon execution by a processor cause the processor to implement the following steps:

in playing audio and/or video using DASH, acquiring a media presentation description (MPD) file and obtaining resolution information through parsing the MPD file;
during the playing of the audio and/or video, periodically determining a currently secure downloading speed according to a preset time interval and determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information; and
in accordance with a determination that the resolution switching is required, determining a switching time point according to an elapsed duration of a currently playing segment and a preset secure buffering duration and performing resolution switching at the switching time point.

[0066] A specific embodiment and process of the foregoing method steps can refer to the first embodiment, which is not repeatedly described in this embodiment.

[0067] The method and device of switching resolution, the computing device, and the readable storage medium provided by the present application can periodically determine whether a resolution switching is required according to a currently secure downloading speed under a preset time interval, and automatically perform resolution switching at calculated switching time points; since the connection establishment time and the network jitter of obtaining segments are taken into account when calculating the secure downloading speed, current network speed can be guaranteed to meet a bandwidth requirement of the resolution after the resolution switching; in addition, performing resolution switching at the switching time points can avoid the situations where the segment corresponding to the resolution after the resolution switching has not been downloaded yet, but the segment corresponding to current resolution has been finished playing, thereby, seamless switching of audio and/or video is ensured, and a phenomenon of switching freeze will not occur.

[0068] It should be noted that, in this article, the terms "including", "comprising" or any other variants thereof are intended to cover non-exclusive inclusion, so that a process, method, article or device including a series of elements includes not only those elements, but also includes other elements not explicitly listed, or elements inherent to such a process, method, article, or device. Without more restrictions, an element limited by the sentence "including a ..." does not exclude that there are other identical elements in the process, method, article, or device that includes the element.

[0069] The above-mentioned serial numbers of the embodiments of the present application are merely for description and do not represent the superiority or inferiority of the embodiments.

[0070] Through the description of the above embodiments, those skilled in the art can clearly understand that the methods in the above embodiments can be implemented by means of software plus a necessary universal hardware platform, and of course, also by hardware, but in many cases, the former is the better implementation.

[0071] The above are only preferred embodiments of the present application, and thus do not limit the patent scope of the present application, any equivalent structure or equivalent process transformation made by using the contents of the specification and drawings of the present application, or directly or indirectly used in other related technical fields are both included in the scope of patent protection of this application.

Claims

1. A method of switching resolution, the method comprising:

   in playing audio and/or video using DASH, acquiring a media presentation description (MPD) file and obtaining resolution information through parsing the MPD file;
   during the playing of the audio and/or video, periodically determining a currently secure downloading speed according to a preset time interval and determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information; and
   in accordance with a determination that the resolution switching is required, determining a switching time point according to an elapsed duration of a currently playing segment and a preset secure buffering duration and performing resolution switching at the switching time point.

2. The method of switching resolution according to claim 1, wherein the resolution information comprises: multiple usable resolutions and bandwidths corresponding to respective ones of the multiple resolutions.

3. The method of switching resolution according to claim 1, wherein the periodically determining a currently secure downloading speed according to a preset time interval comprises:

   obtaining playing information of N segments before the currently playing segment;
   calculating an actual downloading speed of each segment based on the playing information of each segment, and calculating an average downloading speed according to actual downloading speeds of the N segments; and
   multiplying the average downloading speed by a preset secure factor and a percentage to obtain the currently secure downloading speed.

4. The method of switching resolution according to claim 3, wherein the playing information comprises: a connection establishment duration, a downloading duration, and a total downloading byte count, and
   wherein the calculating an actual downloading speed of each segment based on the playing information of each segment comprises:

$$\text{the actual downloading speed} = (8\times \text{the total downloading byte count})/(\text{the connection establishment duration} + \text{the downloading duration}).$$

5. The method of switching resolution according to claim 3, wherein the secure factor is 0.8, and wherein the percentage K is calculated according to a formula of:

$$K=(D-L)/D;$$

   wherein D is a playing duration of one segment; and L is an average connection establishment duration calculated according to connection establishment durations of the N segments.

6. The method of switching resolution according to claim 2, wherein the determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information comprises: adjusting resolutions of subsequently playing segments to be just less than a resolution corresponding to the bandwidth of the secure downloading speed.

7. The method of switching resolution according to claim 1, wherein the determining a switching time point according to an elapsed duration of a currently playing segment and a preset secure buffering duration and performing resolution switching at the switching time point comprises:
   calculating the switching time point T according to a formula of:

$$T=\text{ceil}\left(\frac{C+Q}{D}\right)$$

wherein ceil( ) is a round up function;

C is the elapsed duration of the currently playing segment; and
Q is the secure buffering duration, and Q is equal to 1.5 times the playing duration of one segment, and wherein the resolution switching is performed when playing a T-th segment behind the current segment.

8. A device of switching resolution, the device comprising:

a parsing module for, acquiring a media presentation description (MPD) file and obtaining resolution information through parsing the MPD file, when audio and/or video is played using DASH;
a determining module for, during the playing of the audio and/or video, periodically determining a currently secure downloading speed according to a preset time interval and determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information; and
a switching module for, in accordance with a determination that the resolution switching is required, determining a switching time point according to an elapsed duration of a currently playing segment and a preset secure buffering duration and performing resolution switching at the switching time point.

9. A computing device comprising a memory, a processor, and computer-readable instructions stored in the memory and operable on the processor, wherein the processor, when executing the computer-readable instructions, implements steps of:

in playing audio and/or video using DASH, acquiring a media presentation description (MPD) file and obtaining resolution information through parsing the MPD file;
during the playing of the audio and/or video, periodically determining a currently secure downloading speed according to a preset time interval and determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information; and
in accordance with a determination that the resolution switching is required, determining a switching time point according to an elapsed duration of a currently playing segment and a preset secure buffering duration and performing resolution switching at the switching time point.

10. The computing device of claim 9, wherein the resolution information comprises:
multiple usable resolutions and bandwidths corresponding to respective ones of the multiple resolutions.

11. The computing device of claim 9, wherein the periodically determining a currently secure downloading speed according to a preset time interval comprises:

obtaining playing information of N segments before the currently playing segment;
calculating an actual downloading speed of each segment based on the playing information of each segment, and calculating an average downloading speed according to actual downloading speeds of the N segments; and
multiplying the average downloading speed by a preset secure factor and a percentage to obtain the currently secure downloading speed.

12. The computing device of claim 11, wherein the playing information comprises: a connection establishment duration, a downloading duration, and a total downloading byte count, and
wherein the calculating an actual downloading speed of each segment based on the playing information of each segment comprises:

$$\text{the actual downloading speed} = (8\times \text{the total downloading byte count})/(\text{the connection establishment duration} + \text{the downloading duration}).$$

13. The computing device of claim 11, wherein the secure factor is 0.8, and

wherein the percentage K is calculated according to a formula of: K=(D-L)/D;
wherein D is a playing duration of one segment; and
L is an average connection establishment duration calculated according to connection establishment durations

of the N segments.

14. The computing device of claim 10, wherein the determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information comprises:

adjusting resolutions of subsequently playing segments to be just less than a resolution corresponding to the bandwidth of the secure downloading speed.

15. The computing device of claim 9, wherein the determining a switching time point according to an elapsed duration of a currently playing segment and a preset secure buffering duration and performing resolution switching at the switching time point comprises:
calculating the switching time point T according to a formula of:

$$T=\text{ceil}\left(\frac{C+Q}{D}\right)$$

wherein ceil( ) is a round up function;

C is the elapsed duration of the currently playing segment; and
Q is the secure buffering duration, and Q is equal to 1.5 times the playing duration of one segment, and wherein the resolution switching is performed when playing a T-th segment behind the current segment.

16. A computer-readable storage medium storing computer-readable instructions that upon execution by a processor cause the processor to implement steps of:

in playing audio and/or video using DASH, acquiring a media presentation description (MPD) file and obtaining resolution information through parsing the MPD file;
during the playing of the audio and/or video, periodically determining a currently secure downloading speed according to a preset time interval and determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information; and
in accordance with a determination that the resolution switching is required, determining a switching time point according to an elapsed duration of a currently playing segment and a preset secure buffering duration and performing resolution switching at the switching time point.

17. The computer-readable storage medium of claim 16, wherein the resolution information comprises: multiple usable resolutions and bandwidths corresponding to respective ones of the multiple resolutions.

18. The computer-readable storage medium of claim 16, wherein the periodically determining a currently secure downloading speed according to a preset time interval comprises:

obtaining playing information of N segments before the currently playing segment;
calculating an actual downloading speed of each segment based on the playing information of each segment, and calculating an average downloading speed according to actual downloading speeds of the N segments; and
multiplying the average downloading speed by a preset secure factor and a percentage to obtain the currently secure downloading speed.

19. The computer-readable storage medium of claim 18, wherein the playing information comprises: a connection establishment duration, a downloading duration, and a total downloading byte count, and
wherein the calculating an actual downloading speed of each segment based on the playing information of each segment comprises:

the actual downloading speed = (8× the total downloading byte count)/(the connection establishment duration + the downloading duration).

20. The computer-readable storage medium of claim 17, wherein the determining whether a resolution switching for the audio and/or video currently being played is required according to the secure downloading speed and the resolution information comprises:
adjusting resolutions of subsequently playing segments to be just less than a resolution corresponding to the bandwidth of the secure downloading speed.

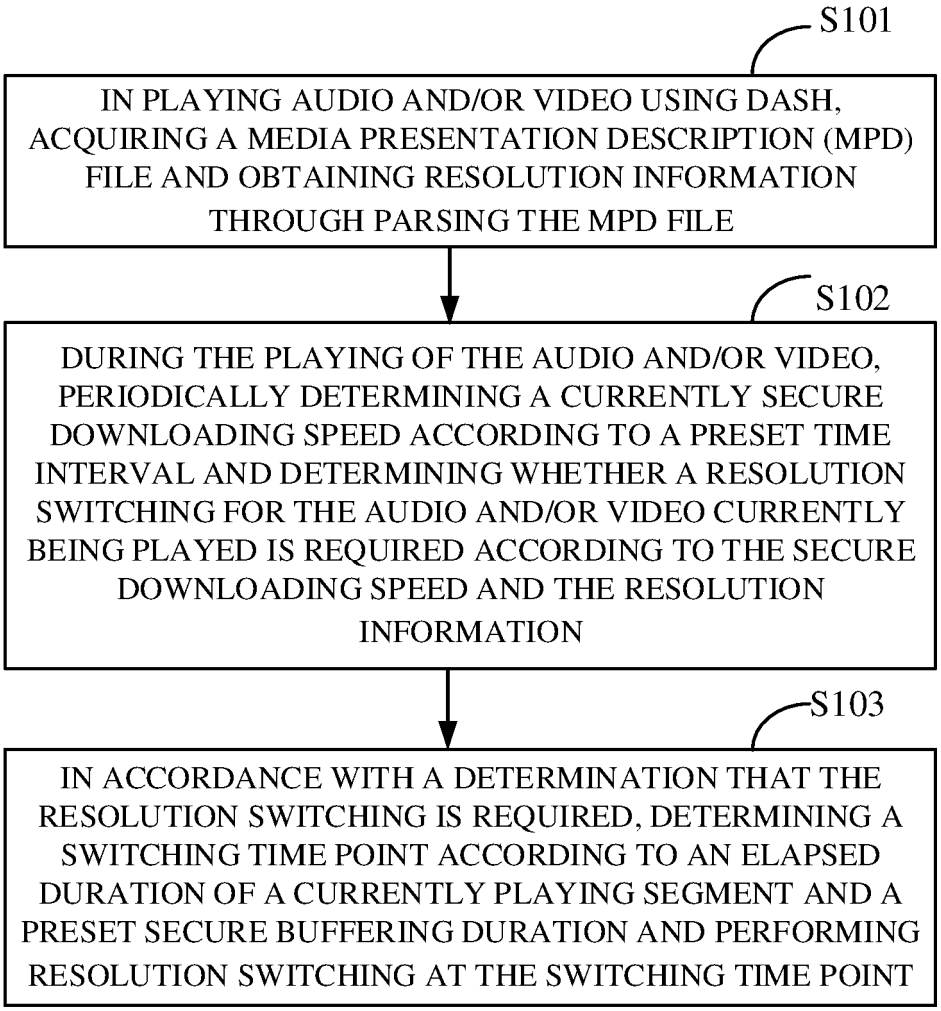
S101
IN PLAYING AUDIO AND/OR VIDEO USING DASH, ACQUIRING A MEDIA PRESENTATION DESCRIPTION (MPD) FILE AND OBTAINING RESOLUTION INFORMATION THROUGH PARSING THE MPD FILE
S102
DURING THE PLAYING OF THE AUDIO AND/OR VIDEO, PERIODICALLY DETERMINING A CURRENTLY SECURE DOWNLOADING SPEED ACCORDING TO A PRESET TIME INTERVAL AND DETERMINING WHETHER A RESOLUTION SWITCHING FOR THE AUDIO AND/OR VIDEO CURRENTLY BEING PLAYED IS REQUIRED ACCORDING TO THE SECURE DOWNLOADING SPEED AND THE RESOLUTION INFORMATION
S103
IN ACCORDANCE WITH A DETERMINATION THAT THE RESOLUTION SWITCHING IS REQUIRED, DETERMINING A SWITCHING TIME POINT ACCORDING TO AN ELAPSED DURATION OF A CURRENTLY PLAYING SEGMENT AND A PRESET SECURE BUFFERING DURATION AND PERFORMING RESOLUTION SWITCHING AT THE SWITCHING TIME POINT

Fig. 1

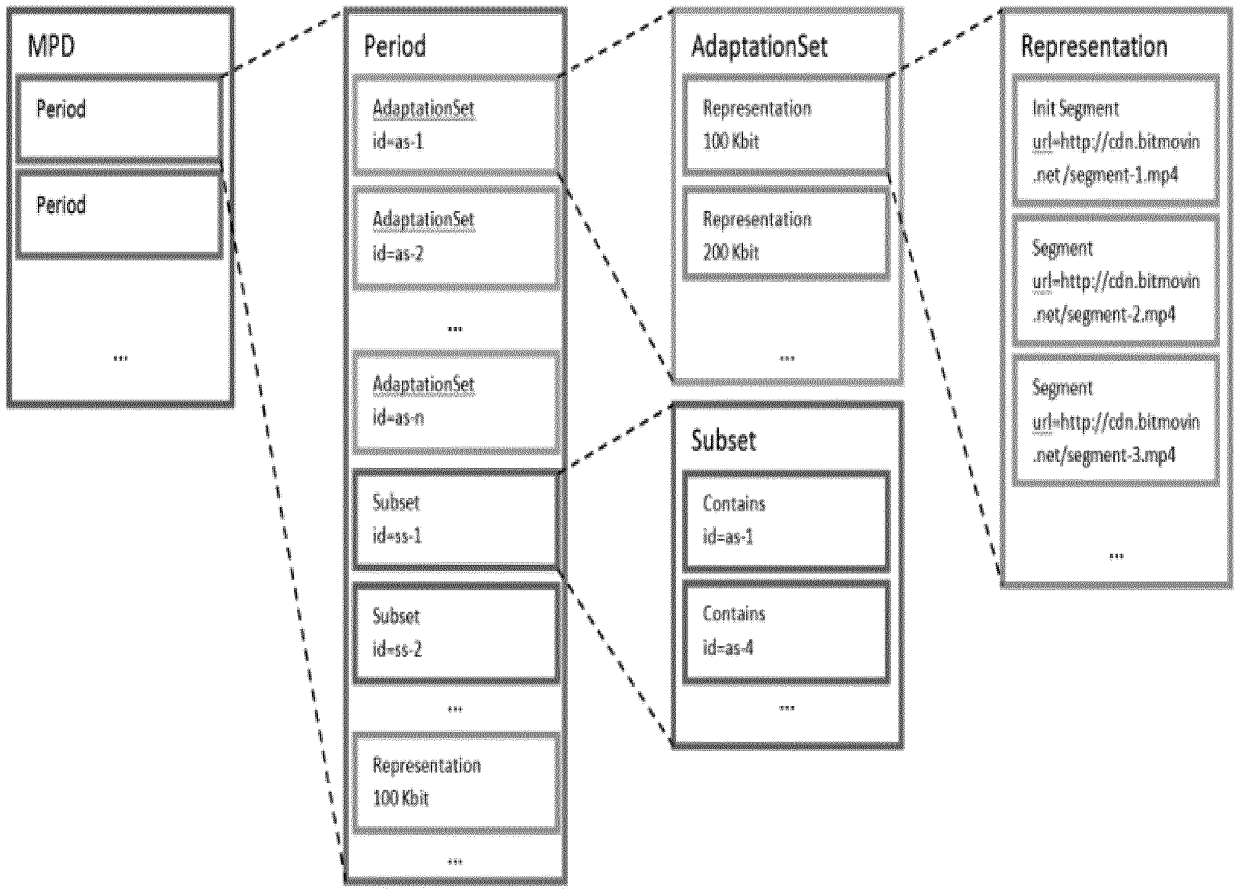
MPD
Period
Period
...
Period
AdaptationSet
id=as-1
AdaptationSet
id=as-2
...
AdaptationSet
id=as-n
Subset
id=ss-1
Subset
id=ss-2
...
Representation
100 Kbit
...
AdaptationSet
Representation
100 Kbit
Representation
200 Kbit
...
Subset
Contains
id=as-1
Contains
id=as-4
...
Representation
Init Segment
url=http://cdn.bitmovin
.net/segment-1.mp4
Segment
url=http://cdn.bitmovin
.net/segment-2.mp4
Segment
url=http://cdn.bitmovin
.net/segment-3.mp4
...

Fig. 2

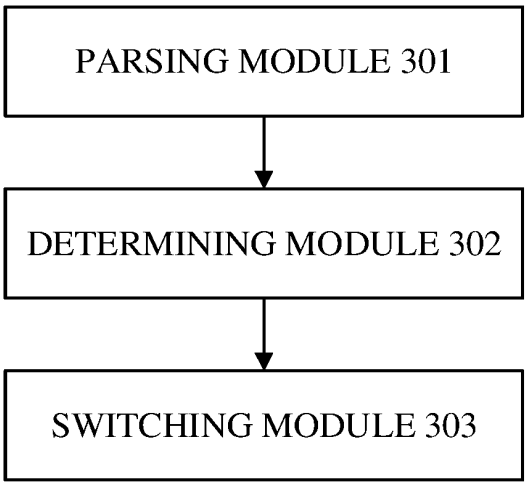
PARSING MODULE 301
DETERMINING MODULE 302
SWITCHING MODULE 303

Fig. 3

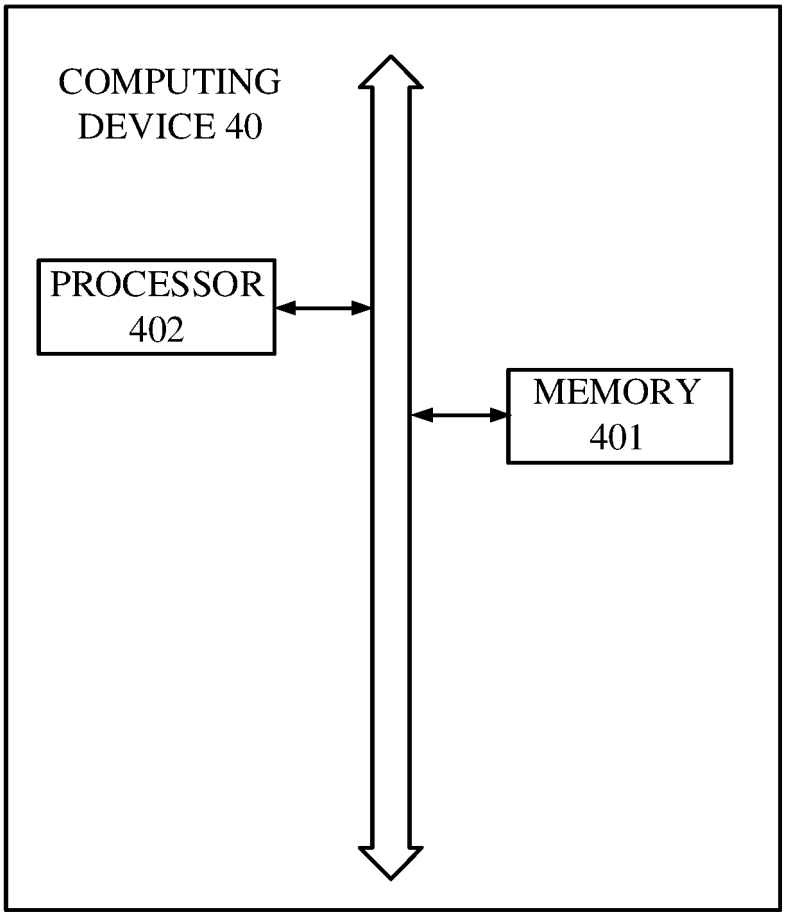

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2019/128448

A. CLASSIFICATION OF SUBJECT MATTER

H04N 21/4402(2011.01)i; H04N 21/845(2011.01)i; H04N 21/2662(2011.01)i; H04N 21/442(2011.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNTXT, CNKI, VEN: DASH, MPD, 清晰度, 分辨率, 码率, 切换, 调整, 调节, 选择, 自适应, 下载, 速度, 网速, 带宽, 切片, 分片, 片段, 缓冲, 无缝, DASH, MPD, definition, resolution, code rate, switch, adjust, select, adapt+, download, network, speed, rate, bandwidth, segment, fragment, chunk, buffer, seamless

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 108271048 A (BEIJING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS) 10 July 2018 (2018-07-10) description, paragraphs [0002]-[0080], and figures 1-4	1-20
Y	CN 108574860 A (1 VERGE (BEIJING) INC.) 25 September 2018 (2018-09-25) description, paragraphs [0065]-[0106], and figures 1-5	1-20
Y	CN 109040855 A (CHONGQING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS) 18 December 2018 (2018-12-18) description, paragraphs [0002]-[0097], and figures 1-4	1-20
Y	CN 106375836 A (GUANGDONG XIAOTIANCAI TECHNOLOGY CO., LTD.) 01 February 2017 (2017-02-01) description, paragraphs [0021]-[0038], and figures 1 and 2	1-20
Y	CN 106993237 A (NORTH UNIVERSITY OF CHINA) 28 July 2017 (2017-07-28) description, paragraphs [0077]-[0148], and figures 1-3	1-20
A	US 2014019635 A1 (VID SCALE, INC.) 16 January 2014 (2014-01-16) entire document	1-20

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 March 2020	**16 March 2020**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088** **China**	Authorized officer
Facsimile No. **(86-10)62019451**	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2019/128448

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 108271048 A	10 July 2018	None	
CN 108574860 A	25 September 2018	None	
CN 109040855 A	18 December 2018	None	
CN 106375836 A	01 February 2017	None	
CN 106993237 A	28 July 2017	CN 106993237 B	10 May 2019
US 2014019635 A1	16 January 2014	TW 201415869 A	16 April 2014
		WO 2014012015 A3	27 February 2014
		WO 2014012015 A2	16 January 2014

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 201910091813 **[0001]**